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ABSTRACT

This paper begins by defining biofeedback and describing some of the major biofeedback machines. An historical perspective is provided of research literature on the relationship of biofeedback and learning. Biofeedback and relaxation are discussed and research is cited for the use of biofeedback techniques in relaxation training with children. Two research projects are presented in greater detail, a study that investigated the use of wrist temperature as a measure of principal brain wave frequency in 30 children, and a study that examined the effects of biofeedback on achievement of normal children by using a combination of alpha, wrist temperature, and autogenic training with 62 middle school children. Other research is reviewed which explored biofeedback training and: (1) achievement in normal children and children with learning disabilities; (2) hyperactive children; and (3) other behavioral changes in self-concept. The benefits of using biofeedback in counseling are discussed and the future of biofeedback techniques in education is considered. (NRB)

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BIOFEEDBACK: ITS USES IN EDUCATION

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BIOFEEDBACK: ITS USES IN EDUCATION

Introduction

Biofeedback is a shortened form for "biological feedback control" which consists of providing an organism with information about a bodily response such as heart rate, skin temperature, blood pressure, and electrical activity in the brain by some mechanical or electronic means so that the organism can learn to adjust or change a response. In the biofeedback training procedure, the otherwise inaccessible signals are amplified, filtered, and displayed with great rapidity. The use of the mechanical or electronic technology for biofeedback was developed mainly in the 1950s and 1960s.

Some of the major biofeedback machines are the galvanic skin response (GSR), the temperature unit, the electroencephalograph analyzer (EEG), and electromyograph analyzer (EMG) (Culligan and Sedlacek, 1980; Brown, 1977).

The galvanic skin response measures autonomic arousal by recording the changing resistance of the skin. The major component is the sympathetically controlled sweat gland. The more the subject perspires, the more the machine reacts. The biofeedback GSR, instead of recording the information on a piece of paper, feeds the information back to the individual by sight or sound. Thus, by reducing the sympathetic arousal, the sound would decrease in pitch. In training with the unit, the individual can explore both high and low levels of sympathetic arousal.

The temperature unit is a sensitive thermister, usually attached to the fingers or hands, that is generally calibrated to show changes of 0.1 to 0.2 degrees. The feedback loop is closed by giving the information of the moment-to-moment temperature change back to the patient via a signal.

The electroencephalograph analyzer (EEG) is used to make a record of the brain wave activity. The human brain produces a continuous output of minute electrical signals. The strength of these signals is so small that it is measured in microvolts, or millionths of a volt. However, the signals can be accurately detected and recorded. To make this measurement, they must first be picked up by electrodes attached to the surface of the scalp and then amplified many thousands of times before they can be analyzed. If these amplified signals are recorded by the tracing pens of an electroencephalograph, the record will appear as a continuous wave of varying frequency and amplitude, and this tracing is called an electroencephalogram, or EEG.

The electromyograph analyzer is used to measure and record muscle contraction and nerve conductance. Sensors are placed on the skin over an appropriate muscle and at a convenient distance from each other, with a third electrode--serving as the electrical reference--placed on a relatively neutral electrical tissue such as over bone. The electrical signals from the underlying muscle are led to the biofeedback instrument where they are amplified and summed over a convenient time period and then used to activate an auditory or visual signal. The EMG signal is generally used as an integrated value that represents the sum of the electrical activity under the sensors, and the biofeedback signal thus

indicates the amount of muscle activity for that time period. The subjects can then easily perceive the biological information fed back to them; they can see the changing intensity of the light signal, the number of light signals activated or the changing values of numbers of a counter and can hear the changing pitch of the auditory signal.

By enhancing sensitivity to psychophysiological processes ordinarily too subtle to be sensed, the individual can develop a measure of voluntary control over normally unconscious and involuntary body processes. Therefore, the use of the machines for learning in both medicine and education is far reaching. This paper will explore research in the literature and of the author in relationship to biofeedback and learning in education.

Historical Perspective

Certain South American Indians have long known that if they dipped their arrows in a substance called curare, the consequence of being shot by such an arrow was almost instant death. Death in such cases is caused by respiratory failure since curare blocks nerve impulses to the musculature, including the respiratory muscles. Other bodily functions are relatively unaffected. For example, human beings who have been injected with curare and kept breathing by artificial respiration verbally report largely unimpaired consciousness. Rats that undergo curare injections followed by artificial respiration will generally fully recover in about three to four hours after being injected by three milligrams of curare (Mednick et al.).

Neal Miller and Leo Di Cara (Mednick et al. 1975) at Rockefeller University have used curare in research on the learning behavior of rats. They used curare to block the rat's muscular movements, while keeping the animal alive through artificial respiration. Miller and Di Cara then attached highly sensitive photoelectric cells to the rat's ears, since photoelectric cells convert light into measurable energy. Light coming through the rat's ears activated these cells. When the blood vessels in the rat's ear were dilated or relaxed, the amount of light passing through the ear was increased. Constriction of the blood vessels in the rat's ear resulted in a decrease in the light that passed through the animal's ear. Miller and Di Cara were thus able instantly to measure vasoconstriction and vasodilation for both of the rat's ears. The experimenters were thus able to train the blood vessels in the left ear to dilate while the right ear did not. Operant conditioning by delivering electrical stimulation to the pleasure center of the rat's brain when the left ear photoelectric cell registered dilation resulted in the rat's learning this highly specific and minute response. Since the right ear did not learn this response, the results were not due to overall changes in heart rate or blood pressure: such factors would have affected both ears.

Miller and his colleagues (Mednick, 1975) also trained rat's heart beats to decrease or increase depending on the light levels of their surroundings, and trained rats to avoid electric shocks to their tails by increasing or decreasing their heart rates. When Miller was asked if human organisms could also control their involuntary emotional and physiological states his answer was, "I believe that in this respect humans

are as smart as rats."

Miller's work relates to research and application of the principles of human and infrahuman learning to biological feedback control.

Since about 1919-20 the alpha brain wave or rhythm, also known as the Berger wave, has been studied (Green and Green, 1977). The alpha wave is the most common wave form of the adult cortex. It is found primarily in the parieto-occipital area when the subject is at rest. Alpha rhythms consist of smooth, regular oscillations at a frequency of 8 to 12 cycles per second. Alpha waves are generally associated with the state of relaxed but alert awareness. They are slow, even, steady EEG waves that are generally blocked or diminished by sensory stimulation and mental activity.

In 1958 Joe Kamiya was struck by the possibility that if a person were continuously informed about one's brain rhythms, as seen by an electroencephalograph (EEG machine), perhaps the subject would be able to turn them on and off at will. He added a relay circuit to an EEG machine to turn a tone on whenever alpha rhythm was present in the occipital cortex and found that college students rapidly learned to control the tone. This finding led Kamiya to begin studying the states of consciousness associated with different kinds of brain waves. Eventually he studied brain-wave patterns in Zen meditators and proposed that it might be possible to develop a "psychophysiology of consciousness" (Kamiya, 1962, 1968).

Barbara Brown's brain-wave research in the early 1960s also focused on the kinds of awareness associated with different brain-wave patterns (1970, 1974). One of her most interesting studies on occipital brain-wave patterns and psychological states involved the use of colored lights that

were turned on and off by specific EEG frequencies. The subject's task was to discover for oneself the subjective states that would operate the lights.

Barbara Brown and others list four main brain wave states--beta, alpha, theta, and delta (Brown, 1977; Green and Green, 1977). The beta waves, from 13 to 25 cycles per second, are associated with normal, focused, rational thought. Alpha rhythms are from 8 to 12 cycles per second and are related to a relaxed, alert, non-focused state. Theta waves, from 4 to 8 cycles per second, are representative of a state of reverie, a twilight state, usually experienced just before sleep and linked to creativity. Delta, below 3 cycles per second, is sleep.

The 1970s, unfortunately, saw the commercialization of so-called "feedback machines" that promised the unwary "instant enlightenment." It was claimed by many unscrupulous persons that biofeedback was a panacea for those who wanted to relax, for those who wanted to develop better memories, or those who wanted to experience "cosmic consciousness."

At this point in the 1980s, the caveat must be raised that serious researchers in the area of biological feedback control are unable to specify the potential of biofeedback control of brain-waves for educational or medical practice. Another caveat is that those of us who are educators must distinguish between the medical and educational uses of biological feedback control.

An example of appropriate application of biofeedback for an educational problem is the reduction of subvocalizations in reading impaired learners. Subvocalization is the "mouthing" of words silently while reading. This behavior limits reading speed to about 150 words per

minute and quickly produces reader fatigue. Curtis D. Hardyck, Lewis E. Petrinovich, and Delbert W. Ellsworth (Mednick et al. 1975) have developed a means of erasing this habit. Their method involves hooking electrodes up to an electromyogram (EMG) after the small metallic electrodes have been placed on each side of the subject's larynx. The subject is seated in a comfortable chair; the technician asks the subject to read by whispering. The muscle movements associated with subvocalization are immediately detected, amplified, and activated to turn on a tone. As soon as the learner can easily turn the tone on and off, treatment begins. The technician asks the learner to read while keeping the tone off as much as possible. As treatment continues, the student learns to keep the tone off, thus eliminating subvocalizations and improving reading ability.

Biofeedback and Relaxation Training

One of the more important uses for biofeedback instrumentation is in teaching the skill of willful eliciting the relaxation response. All of the different types of instruments mentioned earlier can be used in the training for "self-regulatory normalization." The skill is useful for childhood and later adulthood in stress management.

Nature has provided humans with homeostatic mechanisms, such as those, not only to regulate fluid and electrolyte balance, blood pressure, heart rate, and wound healing, but also to readjust more complicated functional disorders that are of a mental nature. The concept assumes that when a person is exposed to excessively disturbing stimulation such as emotional or physical trauma, the brain has the potential to utilize

natural biological processes to reduce the disturbing consequences of the stimulation. Thus, biofeedback training assists the individual in eliciting the relaxation response which helps the body's natural, self-healing mechanisms. The emphasis, then, lies in helping the natural systems use inherent unconscious potentials of self-regulatory adjustment.

The environment in which children live today is filled with tension or too much stress. Hans Selye (1974), the international authority on stress, explains stress as "the body's non-specific responses to any demand made upon it" or the worn and tattered responses of the body. Evidence of too much stress in the child's world is expressed through symptoms such as drug addiction, hyperactivity, irritability, lack of concentration, ulcers, insomnia, asthma, and frequent angry outbursts. Crime and suicide rates in recent years have also increased among youth as a result of frustrations.

In working with children in groups and teaching relaxation skills, it is difficult to have access to numerous precise instruments like the encephalograph analyzers. The author in a recent unit research study investigated the use of wrist temperature as a measure of the principal brain wave frequency in an attempt to find an inexpensive biofeedback technique that would show the relaxation state. The skin temperature at the wrist, an increasing function of the volume of blood circulating to the extremities, seemed a reasonable candidate to be a proxy for the EEG dominant frequency. The study investigated the concurrent validity of the skin temperature at the wrist and the principal frequency of the brain wave. The examination was made during a one-week period with 30 boys and girls, aged 10 to 14 years, who were receiving alpha training. The children were

in an experimental section of a research design which investigated the effects of alpha training on learning.

Conceptually, the investigation sought to assess the association between two measures of relaxation status, the principal brain wave frequency and the wrist temperature. The former measure was made on an Autogen 120a encephalograph analyzer. Two different types of observations were recorded: (1) the instantaneous dominant brain wave frequency (IEEG), and (2) the average dominant brain wave frequency over a 10-minute interval (AEEG). Wrist temperature was measured as Fahrenheit degrees on a Bio-temp band with the temperature sensor on the same side of the left wrist as the palm of the hand. Preliminary checks with the bands showed them to be quite reliable measures of skin temperature.

Students received three sessions, lasting ten minutes each, of biofeedback training to achieve and maintain the alpha state. Five observations of IEEG and wrist temperature were made at two-minute intervals beginning two minutes into each training session, providing fifteen (3 x 5) pairs of measures for each subject. A single AEEG was observed at the end of each training session, providing three measures per subject. Preliminary work with the Bio-temp band alerted the researcher to the effect of ambient room air temperature on the measure of wrist temperature. Consequently, as each wrist temperature measure was observed, a corresponding measure of ambient temperature was recorded. If the ambient and wrist temperatures were associated, the association would tend, the researcher believed, to contaminate the measure of wrist temperature and obscure the association between the brain wave frequency and wrist temperature. The

air temperature measure could be used to "factor out" or residualize the wrist temperature measure for ambient variation.

Several shortcomings of the limited investigation merit attention. First, a wide range of IEEG and AEEG measures would have helped the investigation. The range of such measures in the investigation is sharply truncated, since the students were struggling, with increasing success, to keep the brain wave frequency within a narrow window of values between 8 and 12 Hz. Such truncation usually produces biased measures of association, causing the association to appear weaker than it is. The ambient air temperature measures were made in an air-conditioned classroom, again truncating the range of a variable. Finally, in an optimum investigation, a wide range of wrist temperatures should be observed. In this investigation, wrist temperatures varied much more between subjects than within subjects since each sought that relaxed, at-ease state which is conducive to the alpha brain wave state. These comments illuminate the necessity for extreme care in generalizing these results.

The Pearson correlation coefficient between wrist temperature (w) and ambient temperature (a) was found to be slightly positive ($r = 0.21$, $p < .001$). The correlation between wrist temperature and instantaneous brain-wave frequency (IEEG) was not significant ($r = -0.08$, $p > 1.05$), perhaps because of a high degree of error in the readings of IEEG from a moving needle on the brain-wave analyzer. A much more stable, and therefore reliable, measure is the brain-wave frequency aggregated over a ten-minute period (AEEG).

The correlation between w and AEEG is slight, but negative, as anticipated, and significant statistically ($r = -0.12$, $p < .01$). The researcher concluded, then, that wrist temperature could be used as a rough measure of relaxation status, also measured by the brain-wave frequency. Whereas the weak correlation between the measures rules out the use of wrist temperature as a substitute of brain-wave frequency for individuals, mean wrist temperatures of groups of subjects should be useful as a measure of relaxation status and thus, could substitute for a measurement of brain-wave frequency.

In subsequent referrals to the experiment conducted by the author, the relaxation state was achieved with the boys and girls in the experimental group by either the EEG or wrist temperature for feedback. Table 1 in the appendix shows the before-and after-training wrist temperature for twenty-four days during phase two of the study, and demonstrates that the skin gets warmer as the body relaxes.

Biofeedback Training and Achievement

Biofeedback training has been used to increase achievement of exceptional children. Russell and Carter (1978) report that learning disabled children who learn to relieve their symptoms through biofeedback outside the school are likely to use the same procedures in school learning and moreover such children often acquire the ability to relax when they feel upset or anxious. Learning disabled children who are taught to exercise control over their autonomic system learn to create an internal steady state or constant background in their intrapsychic environment. The value

of internal steady states is that learning occurs in the presence of a fully attentive, attuned, and stable inner state where environmental and physiological background distraction is reduced to a minimum. It can be inferred that the learning of learning disabled children can be facilitated by such children acquiring the ability to increase the steadiness and constancy of their internal states.

Biofeedback training (Carter and Russell, 1978) using EMG feedback from electrodes placed on the forearms of the preferred writing hand, coupled with handwriting training, increased cognitive functioning and certain academic gains assessed through pre- and post-test administration of the Wide Range Achievement Test. Reading, spelling, and arithmetic registered increases. Parents reported their children manifested greater self-control and less impulsivity and distractability. Also present were fewer careless errors in homework and generally greater degrees of conscientiousness in school.

Hunter and his colleagues (1976) report that thermal biofeedback training of learning disabled children through consistent reinforcement enables such children to demonstrate learning almost twice as well as children who received inconsistent reinforcement. Learning disabled children learned thermal digital control more effectually than "normal" children. One probable explanation of this finding is that changes in internal states moved from fluctuations to steady states.

Patmon and Murphy (1978), working with hyperactive adolescent learning disabled children, reported that EEG frequency decrease through biofeedback improved reading as measured by the Wide Range Achievement Test.

EMG relaxation training also resulted in improved attention spans and reduced hyperactive classroom behavior.

One study that raises questions of confidence in biofeedback training with learning disabled children was reported by Gracenin and Cook (1977) who report that alpha biofeedback training does not make a significant difference in oral reading and reading comprehension. It should be noted that these investigators had only 8 students; moreover, biofeedback has been demonstrated in other research to be more effective specifically in reading speed rather than comprehension.

The author was interested in the effects of biofeedback on achievement of normal children. The study mentioned previously in the paper examined the behavior.

The author, when using a combination of alpha (EEG), wrist temperature, and autogenic training with 62 middle school students, did not find a significant difference in achievement between the experimental and the control groups. It was hypothesized that pupils whose study of French was undertaken with alpha training would tend to demonstrate greater overall cognitive achievement in French than comparable pupils whose study of French was undertaken without alpha brain wave training. The students, who volunteered for the eight-week summer program, were grouped randomly for the experimental and control groups. The students received three experiences: a six-week course in French, and two special one-week sessions not associated with French. The order of the latter sessions was reversed to comprise the treatment variable. These two sessions were: (1) a one-week training program of relaxation, aimed at widespread achievement

of the alpha state or pattern, as verified by the EEG, and (2) a one-week activity entitled "Instant Theater Workshop" in which participants performed for their peers in a series of self-expressing exercises. This latter activity served as a placebo and a device for keeping subjects blind to the nature of the research design.

The experimental group received the one-week of alpha training at the beginning of the program while the control group participated in instant theater. This arrangement was reversed the last week of the program. The six weeks of French instruction was the same for the two groups with the exception of the experimental group receiving 10 minutes of alpha training at the beginning of each day's three hours French instructional period. The control group received no special training during the same 10 minutes. To control for teacher variable, the teachers exchanged groups in the middle of the program. The instruction each day consisted of speaking, listening, writing, and reading activities taught with an auditory-visual approach.

Four overall achievement measures were made on all subjects who completed the French classes. The measures were subtests of the Primsleur French Proficiency Test. The subscales were as follows: speaking, listening, writing, and reading. The four scores were summed to produce a total score. Table 2 in the appendix reports the five t-tests for mean differences for each subscale and the total score between the two groups. In none of the comparisons was a mean difference observed which was statistically significant.

Biofeedback Training and Other Behavioral Changes

Biofeedback has been suggested as appropriate for hyperactive or overactive children. Nall (1973), after informally observing what appeared to be positive effects of alpha training with hyperactive children in a special school for children with behavior problems, conducted a study using an alpha training group, a placebo group, and a control group. Comparisons between the training and placebo groups were inconclusive, although Nall noted that the training appeared to be very beneficial with particular children.

Simpson and Nelson (1972) report a preliminary study on breathing control and attention training for hyperactive children. The three experimental children were placed in a cubicle in which they received feedback concerning their breathing rate and the amount of discrepancy from a desired rate. The experimental children were also given attention training, while the control group only worked on tasks in the cubicles. The experimental group showed less breathing irregularity, better performances on tasks and better attending behavior. However, these differences were noticed only in the cubicles and there was no transfer to the classroom setting.

Biofeedback training appears to make children more manageable. Martin and Hershey (1976) studied the effectiveness of biofeedback techniques in reducing the hyperactive behavior of five hyperactive and four nonhyperactive elementary children. After training sessions, the children learned to raise their finger temperatures, increase their attending behavior, and show slight gains in classroom performance and

self-concept. Another study using EMG biofeedback and progressive relaxation indicated that hyperactive children showed less out-of-seat behavior and decreased emotionality and aggressiveness (Braud, 1974).

A reason suggested by Barbara Brown (1977) for behavioral changes of this nature when using biofeedback training is the tendency of the individual to turn the attention inward. This conditioning reduces the amount of attention paid to external factors and leads to a decrease in mental tension or remination about social pressures, and this effect in turn alters the significance that the individual attaches to external environmental situations and stimuli.

It is thought to be important to health that a person feels "in control." J. B. Rotter (1966) spoke of the internal versus external expectancies as the locus of control. It represents the degree to which a person feels that what happens to one depends on one's behavior--a feeling of internal control--as opposed to feeling it is dependent on chance, fate, or is under the control of powerful others--external control. Internal locus of control is not something which is inborn. It must be learned by the individual.

Orne (1965) points out that school can be conceived of as a stressor for a child, which, he reacts to with hyperactivity, and lack of attention. The stimulus, school, is defined as a stressor, not by its objective qualities, but rather by its effect on the individual. Biofeedback training may provide the individual with the internal control needed to deal with the stimulus. Thus, he will tend to be able to tolerate similar stimuli of somewhat greater intensity in the future. Orne concluded by

emphasizing that in order to succeed, individuals must have control over their behavior.

In a research study by the author, behavioral changes in the students who participated in alpha training were observed. As soon as the French lessons began, there was evidence that the experimental group, which received daily autogenic or alpha training, seemed more calm, less overtly competitive, and less likely to exhibit disruptive behaviors. In order to measure the frequency of disruptive behaviors, a simple observation form was developed. Eight types or examples of disruptive behavior were listed for the subject: (1) difficulty concentrating for any length of time; (2) overactivity, restlessness, and/or continual shifting by body positions; (3) disturbing other children by talking, teasing, provoking fights, or interrupting; (4) moving inappropriately out of seat; (5) seeking attention from peers; (6) responding inappropriately to teachers; (7) giggling or laughing inappropriately; and (8) uttering nonsense syllables and/or babbling to oneself. An observer counted the incidence of such behaviors, without regard to the specific type, within a two-minute interval. Observations continued for five consecutive two-minute periods. The total incidences of disruptive behavior were determined by summing the frequency of such behavior in the five time intervals. The observer made all the observations with the observation form. The two classes were observed on the same days during periods in which they participated in similar activities. These pairs of observations were used to test the following research hypothesis: Middle school students who receive relaxation training and daily relaxation exercises will tend to exhibit fewer

incidences of disruptive behavior than comparable students without relaxation training or exercises. The Wilcoxon matched-pairs signed-ranks test (Ferguson, 1971) was used to test the null hypothesis. The test statistic, W+, was found to equal 0.00 and therefore was significant beyond the .005 level of significance. In no pair of observations was the number of disruptive behaviors for the control group lower than that for the experimental group. Refer to Table 3 in the appendix for details of the test.

On the basis of the author's limited research, there appears to be a rather dramatic result related to retention and alpha training. Of the 62 students who enrolled in the French classes, 14 dropped out of the project before its end. While parents were urged to encourage their children's attendance, no extraordinary effort was made to ensure the students' continued enrollment. Care was taken to assure that the two groups were treated alike in the discouragement of dropouts. Of the 14 dropouts, only 3 left the experimental group and one of these was hospitalized and could not complete the lessons. Eleven students dropped out of the control group. Table 4 in the appendix reports the results of a test of the difference of two independent proportions in order to test the following research hypothesis: Students who receive relaxation training will drop out of the French classes at a lower rate than comparable students who receive no relaxation training. The hypothesis is supported at the 0.05 level of significance.

The researcher was interested to determine whether the dropouts in the two groups differed in average intelligence. Intelligence was measured prior to the study using the Otis-Lennon Mental Ability Test, Intermediate

Level, Form J. The mean IQ for the three dropouts in the experimental group was 95.33. The corresponding mean for the eleven dropouts in the control group was 99.09. The standard deviation for the two groups were 6.81 and 11.07 for the experimental and control groups respectively. The observed value of t was not significant ($t = -0.55$, $df = 12$, $p > .10$). Thus, the evidence does not support the contention that the two groups of dropouts differed in academic aptitude.

Biofeedback and Self Concept

Omizo (1980) reports positive results in changing self concept using biofeedback. He studied the effect of relaxation and biofeedback training on five factors of self concept in 52 male hyperactive children, ages 9 to 11, from 5 public elementary schools in a large metropolitan school district. The 5 dimensions of self concept included level of aspiration, anxiety, academic interest and satisfaction, leadership and initiative, and identification vs. alienation.

Omizo's methodology included relaxation training plus visceral feedback on tension level through the electromyometer, the device that measures muscle activity in the frontalis area. Multivariate analysis of variance was used to determine significant differences between experimental and control groups on all dependent variables and post-test EMG measures. He found differences significant at the .01 level or beyond on all the self concept dimensions, except leadership and initiative which was significant at the .05 level. He concluded that relaxation and biofeedback training significantly decreased motor activity. The muscle activity decrease

resulted in significant increases in aspiration, leadership traits, and significant decreases in anxiety.

It appears then that educators can with profit consider both activity and relaxation as interacting variables in teaching learning disabled children and normal children. Activity appears to be essential; however, the activity-relaxation continuum is a highly individualized condition for learning.

Biofeedback and Counseling

Biofeedback is an additional technique useful to the counseling profession. Since the approach emphasizes voluntary self regulation, it can be used for remediation and crisis intervention as well as for personal development, burnout prevention, and stress management.

Not only does biofeedback training encourage voluntary self regulation of physical, mental, and emotional processes, it teaches self responsibility. When the client learns to operate the machine, keep records of personal progress, and set realistic goals from the baseline data, the individual is assuming responsibility for the learning process.

The technique is appropriate for children and adults of all levels of intellectual functioning. For the counselor who works with large numbers of individuals who have limited vocabularies, it is a particularly efficient method. When the client or counselee shares in the therapy, the counselor is freed from excessive verbalization and becomes a facilitator in the self-discovery learning process. The new role is one of a data interpreter and feedback clarifier. The counselor assists the individual

in learning to operate the monitor, read and accept the feedback information for increased self-awareness, and correlate psychological with physiological changes to produce self-regulation.

Some counselors have found a combination of individual counseling plus biofeedback training to be helpful. The combination approach has been particularly useful with alcoholics and other drug addicts (Brown, 1977; Green, 1977). In recent years it has also been tried with child abusers (Danskin and Lowenstein, 1977). Through the use of autogenic tapes, the learning process can continue at home, speeding up therapy. The counselor must understand that maximum benefits are received with daily practice.

Although biofeedback training affects individuals differently, some reports (Danskin and Lowenstein, 1977) indicate general cognitive and affective results that are: improved concentration with fewer breaks, increased memory, improved attitudes of acceptance, high energy levels, a more relaxed state of being, greater self confidence, increased ability to prioritize goals, and a release of creative ideas. Some other benefits are the ability to cope with tension, go to sleep more readily, need less sleep and still be mentally alert, experience less frequent tension headaches, and obviate nervous twitches. Since the method encourages a holistic approach to living, in many cases more than one disturbing condition improves.

Summary

As one can readily see from the research of others and the author in the paper, the use of biofeedback in education is in the stage of infancy. The majority of research has been with learning disabled children and not with normal populations. The research is also contradictory and inconclusive in many instances. Nevertheless, biofeedback appears to be an effective technique in changing various problem behaviors and learning patterns and in teaching relaxation skills.

There are limitations, however, to biological feedback control of which educators must be constantly aware. First of all, it must be recognized that biofeedback training holds no basis for the suspicion that it is the new Orwellian mind control that will characterize the future. Educators who use biological feedback control would be wise to employ its procedures in a spirit of discovery and experimentation.

With the electronic advancements some biofeedback instruments today are priced cheap enough to use with large numbers of students. It is the prediction of the author that educators in the 1980s will use biofeedback technology profusely in the educational arena. The wise use of biofeedback instrumentation may provide an advance in knowledge and technique for training the mind.

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APPENDIX

TABLE 1

DAILY MEAN WRIST TEMPERATURES FOR STUDENTS IN THE EXPERIMENTAL GROUP MEASURED PRIOR AND SUBSEQUENT TO RELAXATION EXERCISES

(N = 24)

	Temperature (^{O}F)		
Date	Before Exercises	After Exercises	Differences
6-15	90.09	90.79	0.70
6-16	89.67	90.21	0.54
6-17	90.81	91.29	0.48
6-18	90.29	90.83	0.54
6-19	90.36	91.86	1.50
6-22	91.14	92.60	1.46
6-23	90.35	91.46	1.11
6-24	88.98	89.71	0.73
6-25	89.91	90.98	1.07
6-26	90.41	91.72	1.31
6-29	88.31	89.96	1.65
6-30	90.58	90.84	0.26
7- 1	89.50	91.19	1.69
7- 2	90.26	91.74	1.48
7- 6	91.19	92.67	1.48
7- 7	91.76	94.33	2.57
7- 8	92.28	93.83	1.55
7- 9	90.96	93.38	2.42
7-10	90.65	92.50	1.85
7-13	89.59	91.70	2.11
7-15	89.21	91.12	1.91
7-16	89.72	91.58	1.86
7-17	89.15	90.71	1.56
7-20	90.71	91.76	1.05
Mean	90.2450	91.6150	1.3700
S	0.9053	1.1495	0.6141

$t_o = 10.93$, $df = 23$, $p < .0005$

TABLE 2

RESULTS OF FIVE T-TESTS FOR MEAN DIFFERENCES BETWEEN EXPERIMENTAL AND CONTROL GROUPS ON THE FOUR SUBSCORES AND THE TOTAL SCORE OF THE PRIMSLEUR FRENCH PROFICIENCY TEST

Group	N	Mean	Standard Deviation	t[a]
		Speaking Subscore		
Experimental	27	41.33	13.11	1.04
Control	20	36.85	16.50	
		Listening Subscore		
Experimental	27	13.11	4.20	-0.40
Control	20	13.60	4.04	
		Writing Subscore		
Experimental	27	5.07	4.53	-0.88
Control	20	6.55	6.96	
		Reading Subscore		
Experimental	27	9.22	3.11	1.09
Control	20	8.30	2.45	
		Total Score		
Experimental	27	68.74	26.29	0.45
Control	20	65.30	25.83	

[a]The critical value of t at the 0.05 level of significance for each test is $t = 1.68$. No observed value of t exceeded the critical value.

TABLE 3

REPORT OF FREQUENCY OF DISRUPTIVE BEHAVIORS FOR THE EXPERIMENTAL AND CONTROL GROUPS WITHIN ELEVEN OBSERVATIONS OF TEN MINUTES EACH

Frequency of Disruptive Behaviors

Observation	Experimental	Control	Difference	Signed Rank
1	5	15	-10	- 6
2	7	13	- 6	- 4
3	1	8	- 7	- 5
4	5	22	-17	-10
5	4	6	- 2	- 1
6	9	28	-19	-11
7	14	27	-13	- 8
8	10	15	- 5	- 3
9	3	15	-12	- 7
10	17	20	- 3	- 3
11	13	27	-14	- 9

The sum of positive signed ranks, W+, equals 0. Such a statistic is significant beyond the .005 level of significance.

TABLE 4

RESULTS OF THE FISHER EXACT TEST OF THE DIFFERENCE OF TWO INDEPENDENT PROPORTIONS OF STUDENTS WHO DROPPED OUT OF FRENCH CLASSES BEFORE THE PROJECT'S END

Total number of students	62
Total number of dropouts	14
Proportion of dropouts	0.23
Proportion remaining	0.77
Control Group	
Number of students	31
Number of dropouts	11
Proportion of dropouts	0.355
Experimental Group	
Number of students	31
Number of dropouts	3
Proportion of dropouts	0.097
Fisher exact probability[a] that the two proportions do not differ.	0.017*

*Significant at the 0.05 level

[a]See Chapter 22, Section 11, of George A. Fergerson's Statistical Analysis for Psychology of Education, 3rd Edition, 1971.